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Influence of Mint and Peppermint on *Tetranychus urticae* and Some Predacious Mites of the Family *Phytoseiidae* (Acari: Tetranychidae: Phytoseiidae)

F. M. MOMEN[1], S. A. A. AMER[1] and A. M. REFAAT[2]

[1] Department of Plant Protection,
[2]Department of Cultivation and Production of the Medicinal and Aromatic Plants,
National Research Centre, Dokki, Cairo, Egypt

The deterrent and toxicity effects of mint, *Mentha virdis* L. and peppermint, *Mentha piperita* L. on *Tetranychus urticae* Koch were studied under laboratory conditions. *M. virdis* was more potent for *T. urticae* than *M. piperita,* with a significant increase in repellency. Leaf discs treated with increasing concentrations of both materials showed reduction in the total numbers of eggs laid. A high percentage of *T. urticae* mortality was recorded in case of *M. virdis*. The direct toxicity of both essential oils to the female of the predacious mites namely *Typhlodromus athiase* Porath and Swirski *Phytoseius finitimus* Ribaga, *Amblyseius barkeri* (Hughes), *Amblyseius zaheri* Yousef and El-Borolossy, *Amblyseius yousefi* Zaher and El-Borolossy and *Amblyseius deleoni* (Muma and Denmark) were tested. At LC_{50} level, *M. virdis* was the most toxic to females *A. yousefi* and the least to females *T. athiasae.* With the exception of *A. zaheri, M. piperita* proved to be more toxic to the predacious mites tested than *M. virdis.* The results obtained chemically and biologically, may suggest that the higher percentage of the hydrocarbons of *M. virdis* were responsible for the toxic effect.

Keywords: *Mentha piperita, Mentha virdis,* Phytoseiidae Predacious mites, *Tetranychus urticae.*

Aromatic plants have traditionally been used in folk medicine. Recently, the interest of the biological activities of extracts has been the subject of intense scientific investigation. Essential oils drived from many plants are known to possess biological activity against prokaryotic (Deans and Ritchie, 1987) and eukaryotic organisms (Konstantopoulou et al., 1992). The existence of different chemotypes, based on qualitative differences within a taxon, is a common feature in most *Mentha* species and hybrids (Kokkini, 1991). Summarizing research published to date, it can be concluded that the main monoterpenes which characterize the essential oil composition of the different species and hybrids are either cyclic C-2 (such as carvone, hydrocarvone) or C-3 (such as menthone, pulegone) substituted compounds (Kokkini, 1992).

Recently, mites infesting food products became a dangerous problem, also the rise of resistance among its population implied the necessity need to look for combinations of acaricides of different modes of action as alternative methods of mite control, to face the serious problems created by using acaricides. The utilization of some plants against the mite attack, have prompted us to initiate a program for using plant extracts for the biological activity. Among these botanicals, the essential oils which exhibit antifeedant activity and toxic to some important insects (Su et al., 1972; Don-Pedro, 1985; Tare and Sharma, 1988). The effect of the essential oils on pest mites has been studied by Amer et al. (1993); Ibrahim et al. (1993); Perrucci (1995); El-Gengaihi et al.

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(1996); Amer et al. (in prep.). The role of phytoseiid mites as predators of phytophagous mites and insects on various kinds of crops is well documented (Huffaker et al., 1970). However, the phytoseiid predators, *A. barkeri, A. zaheri, T. athiasae, A. deleoni, A. yousefi* and *P. finitimus* have been evaluated for control of spider mites on crops and orchards with promising results (Swirski et al., 1967; El-Banhawy, 1974; Momen, 1995; Abou-Elella, 1998; Momen and El-Borolossy, 1999). Therefore, in the presence of essential oil applications, biological control of spider mites may be achieved by the selective use of essential oil that are less toxic to natural enemies than to pest species. The present work was carried out to complete previous work discussed the activity of some essential oils on the pest *T. urticae* which is very harmful to agriculture. Knowledge of the effects of both materials tested on natural enemies of phytophagous mites and insects is also provided.

Materials and Methods

Plant materials

The essential oil of mint and peppermint plants was obtained during the last week of June 1997 from plants grown in the Experimental farm of National Research Centre at Giza.

Preparation of the oil

The air-dried plant material (aerial parts) was pulverized and the essential oils isolated after hydrodistillation for 3 hours using Clevenger apparatus. The freshly distilled oil of each plant was dehydrated over anhydrus sodium sulphate and then subjected to GC-MS analysis under the following conditions: Apparatus: Varion 3400 gas chromatograph with mass selective detector operated in electron ionization mode at 70 ev. The column used for oil separation was a fused silica DB-5 column, 30 m x 0.25 mm i-d., film thickness 0.25.

Chromatographic investigation of the volatile oil. Mass spectra were obtained by a Hewlett-Packard 5890 gas chromatograph coupled with mass detector. Carrier gas: helium at 1 ml/min., temp. programming 60–200 ºC at rate of 3 ºC/min.; chart speed: 0.6 cm/min., injection part temp.: 150 ºC; split ratio 100:1; start stop masses 39–250; electron multiplier voltage 1800 ev. Identification of the constituents was performed by comparison of their retention times and mass spectral fragmentations with those of the published data by Adams (1989). Quantitative determination was carried out based on peak area measurements.

Preparation of the emulsions

Emulsions of mint *(Mentha virdis)* and peppermint *(Mentha piperita)* were prepared by mixing of Triton-x 100. Different concentrations of the product were prepared and tested against the adult females of mites.

Maintenance of mite stock cultures

The stock cultures of *T. urticae* were collected from infested lima bean (*Phaseolus vulgaris* L.) in the laboratory at N. R. C. Cairo. The following predacious mites were used in our studies, *A. zaheri* and *A. barkeri* were found on leaves of eggplants; *P. finitimus* was collected from fig oechards; *A. deleoni* and *T. athiasae* were found on mango leaves; *A. yousefi* was found on leaves of *Zizyptus spina-christi,* L. All these strains have been maintained in the laboratory for 3 years. All strains were kept separately on detached bean leaves *P. vulgaris* placed on wet cotton wool with *T. urticae* as prey.

Treatment

REPELLENCY AND TOXICITY TEST PROCEDURE FOR ADULT FEMALES OF *T. URTICAE*

Raspberry leaf discs (3 cm in dia.) were placed with the lower surface upwards in a petri-dish lined with moist cotton wool. One half of each disc was treated separately with selected concentrations of both oils, while the other served as a control. Ten adult females of *T. urticae* were then introduced into the middle of each leaf disc. Ten replicates leaf discs were used per concentration. Orientation of the females *T. urticae* on treated and control discs recorded after 24, 48 and 72 h after treatment. The number of eggs laid on both sides and the percentage mortality of adult females were recorded after 72 h. The repellency was calculated according to Lwand et al. (1985).

TOXICITY AND BIOLOGICAL EFFECTS OF MINT AND PEPPERMINT ON ADULT FEMALES OF *T. URTICAE*

Newly emerged females *T. urticae* were transferred singly on raspberry leaf discs treated with different concentrations of mint and peppermint. The total number of eggs laid were recorded over a period of 10 days. The mortality of the females was also recorded. Each concentration was replicated 20 times and a similar number of discs treated with water only as a control. The different indices were calculated as reported by Lundgren (1975).

DIRECT EFFECT ON SOME PREDACIOUS MITES

Adult females of 6 predators species *(A. barkeri, A. deleoni, A. zaheri, A. yousefi, T. athiasae* and *P. finitimus)* were sprayed with different concentrations from both materials using glass atomizer. Females were confined on the lower surfaces of detached raspberry clean leaves (5 cm in dia.) while the upper surfaces were placed on cotton saturated with water. Each test contained 5 concentrations and each concentration had 4 replicates (20 females/replicate). In every test, a control was included. Mortality was recorded 48 h after application. Corrected mortality counts according to Abbott's formula (1925) and were statistically analysed by Finney (1952).

All the experiments reported herein were carried out the laboratory at 27±2 ºC and 70–75% R. H.

Results and Discussion

Chemical constituents of mint and peppermint oils

Qualitative and quantitative analysis of mint *(M. virdis)* and peppermint *(M. piperita)* essential oils showed that both oils were mainly characterized by high concentration of total terpene compounds (88.53 and 92.67%) respectively, and low concentration of sesquiterpenes (11.48 and 7.34%) respectively, although their individual levels varied, in particular the concentration of some components such as, menthon (1.999 and 25.145%) respectively, in addition, the variation in the individuals inside either oils.

Tables 1, 2, 3, 4 and *Figs 1, 2* also show that mint oil was mainly characterized by high concentration of carvone (57.351%), while menthone and menthol represented the main components in peppermint oil since they formed 25.145 and 21.633% of oil content respectively.

Repellency, mortality and oviposition deterrence

Table 5 shows that mint oil at all concentrations used, strongly deterred *T. urticae* adult females. At the lower concentration of mint oil, a considerable percent of *T. urticae* was recorded on treated half. Mortality was extremely high at 2% conc. after 72 h and was slightly at 0.125% conc. Percent repellency gradually decreased with peppermint oil concentrations. Mortality was nil and the number of eggs laid by females *T. urticae* after 72 h of treatment varied according to concentrations of peppermint oil *(Table 5).* No eggs were laid in case of mint oil. Harwood et al. (1990) demonstrated that reduced growth in larvae of the noctuid *Peridroma saucia* was the result of feeding inhibition in larvae fed menthone and pulegone and moulting abnormalities in larvae receiving menthol, as well as completely inhibited pupation. The essential oil of *M. piperita* was active against adult of *Tribolium castaneum* (Hbst) and toxic also to the newly hatched larvae of *Pectinophora gossypiella* (Saund.) and *Earias insulana* (Boisd.) (Shaaya et al., 1991; Hewady et al., 1994). Similar result has been also reported, that the essential oil of *M. piperita* and some of its main constituents (menthone and menthol) exhibited powerful acaricidal activities against *Tyrophagous longior* by direct contact and by inhalation (Perrucci et al., 1996). *Tables 1, 2* show that the hydrocarbon terpenes and hydrocarbon sesquiterpenes content in mint was higher than on peppermint oil.

Chavan (1984) and Siddiqui et al. (1988) demonstrated that the hydrocarbon fraction isolated from dried neem leaves and twigs possessed larvicidal activity against mosquitoes. Similar results were recorded on *T. urticae* by El-Gengaihi et al. (1999), showing that the leaves of Moghat contained some hydrocarbons, so these hydrocarbons may be responsible for the effect itself or its occurrence with other hydrocarbons may cause synergistic effect, and finally increased activity.

Concentration effects on reproduction and mortality

Reproduction of *T. urticae* was greatly affected by both oils treatment. Significant reduction in the total number of eggs laid during 10 days period were found for all

Table 1

Hydrocarbon terpenes content in mint and peppermint essential oils

Peak No.	Mint oil	%	Peak No.	Peppermint oil	%
1	α-Thujene	0.011	1	Tricyclene	0.047
2	α-Pinene	0.421	2	α-Pinene	2.576
3	Camphene	0.110	3	Camphene	0.078
4	Sabinene	0.230	4	Sabinene	0.752
5	β-Pinene	0.547	5	β-Pinene	2.185
6	Myrcene	0.240	6	Myrecene	0.510
8	D-Limonene	14.162	8	D-Limonene	3.538
9	cis-Ocimene	0.028	10	cis-Ocimene	0.065
10	trans-Ocimene	0.005	11	trans-Ocimene	traces
11	γ-Terpinene	0.006	12	γ-Terpinene	0.035
	Unknown	0.080		Unknown	0.905
	Total	15.840		Total	10.746

Table 2

Oxygenated terpenes content in mint and peppermint oils

Peak No.	Mint oil	%	Peak No.	Peppermint oil	%
7	2-Octanol	0.369	7	3-Octanol	1.159
12	cis-p-menth-2-en-1-01	0.021	9	Cineole	0.123
13	trans-Linalool oxide	0.014	13	Cis-p-menth-2-en-1-01	0.055
14	α-Pinene oxide	0.074	14	Cis-Linalool oxide	0.008
15	Linalool	0.076	15	Fenchone	0.044
16	Menthone	1.997	16	Linalool	0.009
17	trans-Dihydro terpineol	1.591	17	Camphor	0.122
18	Neomenthol	0.575	18	Menthone	25.145
19	Dihydro carveol	0.138	19	Isomenthone	8.379
20	new iso-Dihydro carveol	0.036	20	Newmenthol	8.782
21	Carvone	57.351	21	Menthol	21.633
22	Isomenthyl acetate	0.641	22	α-Terpineol	0.204
23	Terpinenyl acetate	6.030	23	Pulegone	3.252
24	cis-Carvyl acetate	0.877	24	Pipritone	3.213
27	cis-Jasmone	0.192	25	Bornyl acetate	3.707
29	Ionone	0.220	26	Isomenthyl acetate	0.373
	Unknow	2.481	27	trans-Carvyl acetate	0.056
	Total	72.683	29	Eugenol	traces
			30	cis-Carvyl acetate	0.114
			33	Jasmone	0.082
				Unknown	5.514
				Total	81.919

Table 3

Hydrocarbon sesquiterpenes content in mint and peppermint oils

Peak No.	Mint oil	%	Peak No.	Peppermint oil	%
25	β-Bourbonene	3.065	28	D-Elmene	0.190
26	β-Cubebene	0.907	31	Copaene	0.088
28	β-Caryophyllene	2.704	32	β-Bourbonene+β-cubebene	1.129
30	β-Gurjunene	0.253	34	β-Caryophyllene	2.068
31	Aromadendrene	0.545	35	α-trans-Bergamotene	0.159
32	β-Farnesene	0.147	36	Aromadendrene	0.033
33	γ-Muurolene	0.199	37	β-Farnasene	0.156
34	D-Germacrene	0.163	38	Germecrene D	1.050
35	α-Muurolene	0.125	39	α-Longipinene	0.081
36	α-Farnesene	0.012	40	β-Bisabolene	traces
37	γ-Cadinene	0.112	41	γ-Cadinene	0.332
38	15-cis-Calamenene	0.076		Unknown	0.518
	Unknown	1.444		Total	5.824
	Total	9.752			

Table 4

Oxygenated sesquiterpenes content in mint and peppermint oils

Peak No.	Mint oil	%	Peak No.	Peppermint oil	%
39	Caryophyllene oxide	1.160	42	Nerolidol	0.047
40	τ-Cadinol	0.025	43	Spathulenol	0.013
41	α-Cadinol	0.033	44	Caryophyllene oxide	0.384
	Unknown	0.507	45	τ-Cadinol	0.066
	Total	1.725	46	α-Cadinol	0.058
			47	α-Bisabolol	0.019
				Unknown	0.934
				Total	1.521

the concentrations tested *(Table 6).* The depression in total number of eggs with high concentrations could be attributed to feeding inhibition and irritant effects of the formulation, causing depression on reproduction activity. Similar results have been reported by Gulati and Mathur (1995) indicating that mentha leaf powder was effective in bring about a decrease in the fecundity of *Tyrophagous putrescentiae* (Schrank) and reducing the mean egg numbers to 25.49/female as compared to 98.16 egg/female in the control. Mortality percentage reached 100% with mint oil, however, with low concentration, the effect was pronounced with mint oil than peppermint oil. Mansour et al. (1986) reported that the most effective oil on *Tetranychus cinnabarinus* (Boisd) was *M. piperita.* In contrast the oil was not effective on *Acanthoscelides obtectus* Say a pest of bean *Phaseolus vulgaris* (L.) (Regnault-Roger and Hamraoui, 1993). The same authors in (1995)

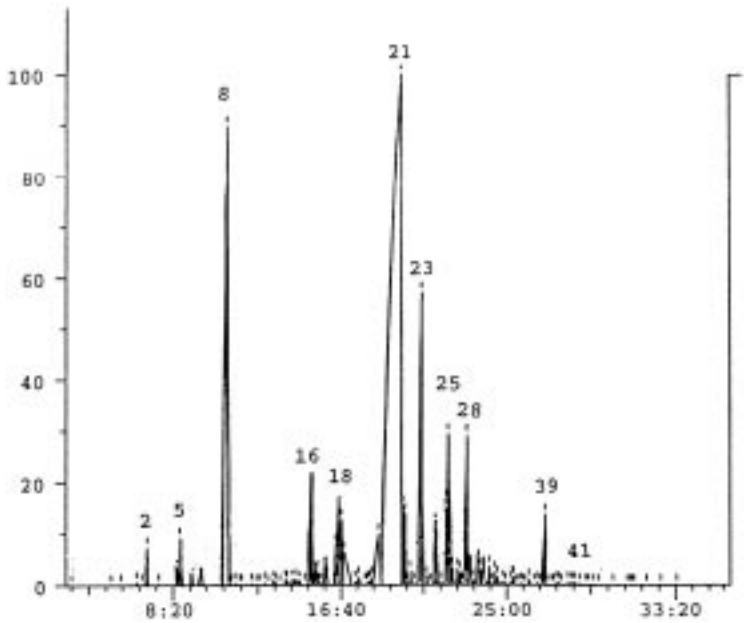

Fig. 1. Chromatogram of mint essential oil

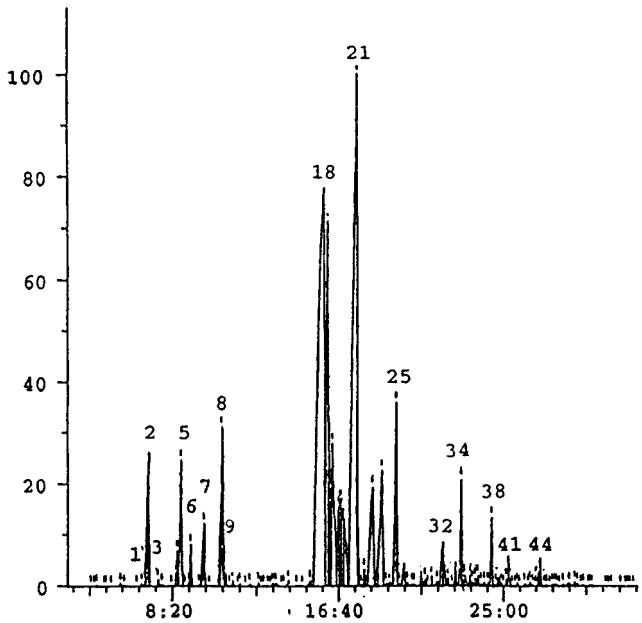

Fig. 2. Chromatogram of peppermint essential oil

suggested that lipid as well as nonlipid allelochemical, such as phenolics, or nonprotein amino acids or flavonoids, may be involved in the toxicity of hydrodistillated and intact plant extracts from *M. piperita* to *A. obtectus.*

Table 5

Phagodeterrent activity of mint and peppermint oils against females of *T. urticae*

% Concentrations	% Distribution of mites on treated leaf part after			% Mortality after	Avg. No. of eggs/female after		% Repellency
	24 h	48 h	72 h	72 h	72 h		
					T	C	
				Mint oil			
2	0	0	0	75	0	0.05	100
1	0	0	0	40	0	0.15	100
0.5	0	0	5	20	0	0.65	100
0.25	0	0	15	15	0	0.7	100
0.125	0	10	20	10	0	1.55	100
				Peppermint oil			
2	15	15	20	0	0.05	0.5	90
1	20	20	20	0	0.2	1.4	85.7
0.5	25	30	35	0	0.3	1.4	78.6
0.25	35	45	50	0	0.85	1.95	56.4
0.125	45	55	55	0	1.05	1.95	46.2

C = control; T = treated

Table 6

Effect of mint and peppermint oils on reproduction and mortality of *T. urticae*

% Concentrations	Mint oil			Peppermint oil		
	Total no. of eggs/female/10 days ± S. E.	% ODI	% Mortality after 10 days	Total no. of eggs/female/10 days ± S. E.	% ODI	% Mortality after 10 days
2	0±0	100	100	0±0	100	58.33
1	0.55±0.11	98.14	80	0±0	100	21.43
0.5	5.7 ±0.33	82.24	66.67	3.90±0.22	87.5	18.18
0.25	6.2 ±0.33	80.83	46.67	7.65±0.25	76.87	0.00
0.125	8.75±0.25	73.98	26.67	9.0 ±0.15	73.33	0.00
Control	58.5±0.45	–	–	85.5±0.45	–	0.00

High signigicant $\leq 0.01\%$

Direct effect of mint and peppermint oils on adult females of some predacious mites

The data obtained in *Tables 7* and *8* show that adult females of *A. yousefi* was more sensitive ($LC_{50} = 2.954\%$) to mint oil, while females of *T. athiase* was less susceptible ($LC_{50} = 16.15\%$). Results indicated also that peppermint oil was more toxic to the predacious mites tested than mint oil except for females of *A. zaheri.* Sopp et al. (1990)

Table 7

Toxicity of mint oil to females of some predacious phytoseiid mites

Species	% LC_{50}	% LC_{90}	Slope	Toxicity index at		No. of folds compared with *T. athiasae* at	
				LC_{50}	LC_{90}	LC_{50}	LC_{90}
A. yoseffi	2.954	11.81	2.13	100	100	5.47	15.66
A. zaheri	5.530	42.50	1.45	53.42	27.79	2.92	4.35
P. finitimes	6.882	14.77	3.86	42.92	79.96	2.35	12.52
A. barkeri	8.796	31.25	2.33	33.58	37.79	1.84	5.92
A. deleoni	12.09	114.2	1.31	24.43	10.34	1.34	1.62
T. athiasae	16.15	184.9	1.21	18.24	6.39	1.00	1.00

Table 8

Toxicity of peppermint oil to females of some predacious phytoseiid mites

Species	% LC_{50}	% LC_{90}	Slope	Toxicity index at		No. of folds compared with *A. zaheri* at	
				LC_{50}	LC_{90}	LC_{50}	LC_{90}
T. athiasae	1.90	65.72	0.83	100	8.23	13.3	11.22
A. yoseffi	2.314	6.277	2.95	82.11	86.19	10.92	117.48
P. finitimes	2.890	9.504	2.47	65.74	56.92	8.74	77.59
A. deleoni	2.92	19.14	1.57	65.07	28.27	8.65	38.53
A. barkeri	3.72	5.41	7.89	51.08	100	6.79	136.30
A. zaheri	25.27	737.40	0.87	7.52	0.73	1.00	1.00

reported that *Phytoseiulus persimiles* A. H. was relatively unaffected by the beta-acids showing only a small reduction in the number of eggs laid. Mansour et al. (1993) revealed that RD9-Repelin was highly toxic to *T. athiasae* but Margosan-O and Azatin were not toxic. Research carried out by Momen and Amer (1994) and Momen et al. (1997) demonstrated that Lupin and canna extracts were toxic to females *A. barkeri,* also Neem Azal-F appeared to be harmless for *A. barkeri* and *A. zaheri.* Pyrethrum and rotenone had a negative effect on *Typhlodromus exhilaratus* Ragusa, and also stinging nettle and bitter wood were not effective on the predator (Tsolakis et al., 1997).

Conclusion

On scrutinizing our results, it will be shown that *M. virdis* is satisfactory as regards both high mortality and low reduction of fecundity for *T. urticae. M. virdis* was more toxic to *T. urticae* than to phytoseiid predators studied. In contrast, *M. piperita* was

more effective on most phytoseiid predators than *M. virdis,* as well as it was considered to be less toxic to *T. urticae* than *M. virdis.* However, *M. virdis* can protect agricultural crops by direct or delayed pesticidal effect, through increased adult mortality and inhibition of reproduction. In integrated control programmes, therefore a careful choice of essential oil should be made to harm phytoseiid populations as little as possible. Consequently, knowledge about possible adverse affects of specific essential oil is essential. Field and laboratory data on the toxicity of such compounds to predacious mites should be obtained.

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